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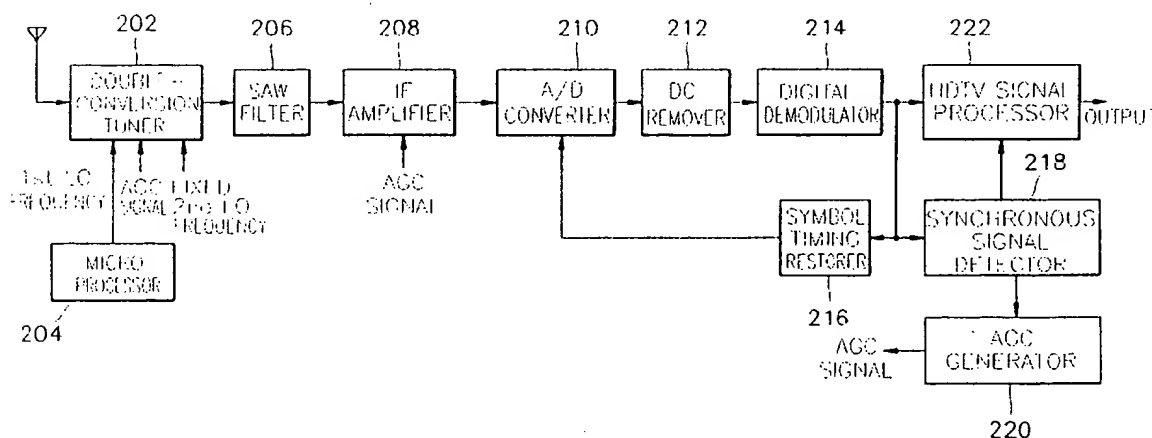
Halifax, West Yorkshire HX1 2HY (GB)

(54) Digital demodulator and method therefor

(57) A digital demodulator removes frequency and phase errors existing in a digital signal and converting the error-removed digital signal into a base band signal. The digital demodulator uses a frequency being twice

the transmission rate as the frequency of the sampling clock signal of an analog-to-digital (A/D) converter, and demodulates a received signal in a digital processing using a low-speed A/D converter. Thus, all of the received signal processing can be digitized.

FIG. 2



Description

The present invention relates to a receiver for receiving a high-definition signal, and more particularly, to a digital demodulator for a high-definition television (hereinafter, referred to as HDTV) receiver, and a method therefor.

Since the advent of the black and white television and the colour television, there has been a continuing trend to develop televisions that are more realistic, larger and have better definition. Accordingly, the grand alliance (GA)-HDTV system has been proposed in the U. S. in which a vestigial side band (VSB) modulation method is adopted as a modulation method of the GA-HDTV. Accordingly, as the HDTV transmission standard of the USA is determined as an 8-VSB modulation method, HDTV broadcasts will be realized in the near future.

Meanwhile, the demodulation of an existing GA-HDTV receiver is performed using an analog demodulation method. After analog demodulation of a receiving signal, digital signal processing is performed to restore the original signal.

Figure 1 is a block diagram of a conventional GA-HDTV receiver using an 8-level VSB modulation method. Referring to Figure 1, a received radio frequency (RF) signal is output as an intermediate frequency (IF) signal through double-conversion by a double conversion tuner 102. That is, a synthesizer 104 provides a first local oscillation (LO) frequency to the double converting tuner 102 according to channel tuning. A first mixer (not shown) in the double conversion tuner 102 mixes the received RF signal with the first local oscillation (LO) frequency to thus output a first IF signal of a predetermined frequency (920MHz), and then constantly adjusts the amplitude of the first IF signal according to an automatic gain control (hereinafter, referred to as AGC) signal which is generated from an AGC generator 138. At this time, channel tuning is controlled by a microprocessor (not shown). The automatic gain-controlled first IF signal is mixed with a second LO frequency, which is controlled by a frequency and phase-locked loop (FPLL) circuit 111, in a second mixer (not shown) of the double converting tuner 102 and output as a second IF signal of a desired predetermined frequency (44MHz).

The double converting tuner 102 does not accurately pass only HDTV signals having a 6MHz band but also passes co-channel signals, since its filtering characteristics are not perfect. The co-channel signals cause interference with signals of a desired channel. Accordingly, in order to solve the above problem, the output of the double converting tuner 102 passes through a surface acoustic wave (SAW) filter 106 corresponding to a band pass filter having a bandwidth of exactly 6MHz.

An IF amplifier 108, for continuously maintaining the level of an input signal of an analog-to-digital (A/D) converter 132, controls the amplitude of the IF signal passed through the SAW filter 106 according to the AGC signal generated from the AGC generator 138.

A multiplier 110 multiplies the IF signal of 6MHz bandwidth passed through the SAW filter 106 by a sinusoidal wave signal output from a phase shifter 114 which receives a fixed third LO frequency which is generated from a local oscillator 112, thus outputting a signal demodulated into a base band. Here, the first multiplier 110 corresponds to a third mixer, and the fixed third LO frequency is 46.69MHz corresponding to a pilot frequency.

A first low-pass filter (LPF) 116 removes a second-order harmonic component generated after demodulation and passes only base band signals. The first LPF 116 outputs an I signal on an in-phase axis. Here, when automatic frequency control (AFC) is made during frequency acquisition, an I signal, a Q signal on a quadrature-phase axis and a pilot signal are all used. However, in other data processing blocks of a receiver, only the I signal is used.

That is, an automatic frequency control low pass filter (AFC LPF) 118 outputs beat signals which are generated by a difference in frequency between the output of an internal voltage controlled oscillator (VCO) and input pilot signals. Accordingly, the radio frequency is almost removed by the AFC LPF 118 while only the pilot beat frequency remains.

A limiter 120 outputs "+1" when the output of the AFC LPF 118 is larger than "0," and otherwise, outputs "-1." Thus, the pilot beat signal is limited to a signal ± 1 having a constant amplitude (± 1).

Meanwhile, a second multiplier 122 multiplies the IF signal output from the IF amplifier 108 by the fixed third LO frequency output from the local oscillator 112, thus outputting a signal Q on a quadrature-phase axis.

A second LPF 124 removes a second-order harmonic component from the output of the second multiplier 122 in the same manner as that of the first LPF 116 and passes only the Q signal having a base band. A third multiplier 126 multiplies the output of the limiter 120 by the output of the second LPF 124. Thus, the result of the multiplication drives an automatic phase control low pass filter (APC LPF) 128.

The APC LPF 128 outputs a "direct current (DC)" signal, and drives a VCO 130 according to the DC signal. That is, the DC signal output from the APC LPF 128 is fed back to the double-conversion tuner 102 to reduce the above-described difference in frequency and controls the second LO frequency.

When the frequency is locked by repeating such operations, the limiter 120 outputs either "-1" or "+1." At this time, the third multiplier 126 locks the output of the second limiter 120 into the phase of the third fixed LO frequency which is output through the second LPF 124. Through such a control process, phase errors of a carrier frequency in a base band frequency become "0."

Meanwhile, an A/D converter 132 samples the output of the FPLL circuit 111 according to a symbol clock signal restored by a symbol timing restorer 134 and converts it into digital data. The symbol timing restorer 134 generates a symbol clock signal and an operational

clock signal of the entire system by predicting a sampling point in time of an analog-to-digital (A/D) converter 132. A synchronous signal detector 136 detects a variety of synchronous signals using the output signal of the A/D converter 110 and outputs a synchronous signal necessary for each portion to an HDTV signal processor 142, and detects a data segment synchronous signal and outputs the result to the AGC generator 138. The AGC generator 138 generates an AGC signal according to the amplitude of the data segment synchronous signal and applies the result to the double conversion tuner 102 and the IF amplifier 108.

A DC remover 140 removes a DC component generated by the nonlinear characteristic of the A/D converter 132. An HDTV signal processor 142 processes the output of the DC remover 142 and restores the result to the original signal.

As described in Figure 1, the FPLL circuit 111 as an analog demodulator of an HDTV receiver provides an obstacle to the miniaturization of a system. Therefore, if a digital demodulator is realized instead of the analog demodulator, the entire signal processing of a receiver can be digitalized. In this case, it is easy to develop a demodulator using a single ASIC chip, and low cost of receivers and uniform performance thereof can be ensured.

However, since the conventional digital demodulator directly samples an IF signal of 44MHz, it should use a frequency, being twice or greater than the IF signal frequency (44MHz), as a sampling frequency. Accordingly, a high-speed A/D converter is required with a result that costs increase.

With a view to solve or reduce the above problems, it is an aim of preferred embodiments of the present invention to provide a digital demodulator for digitalizing the processing of every received signals while using a low-speed A/D converter, in a receiver for receiving a high-definition signal.

It is another aim of embodiments of the present invention to provide a demodulation method for digitalizing the demodulation processing of received signals, in a receiver for receiving a high-definition signal.

According to a first aspect of the invention, there is provided a digital demodulator for removing frequency and phase errors existing in a digital signal and converting the error-removed digital signal into a base band signal, for use in a receiver for receiving a high-definition signal, said digital demodulator comprising: a phase splitter for splitting said digital signal into a first signal having a real number component and a second signal having an imaginary component; a complex multiplier for multiplying said first and second signals by first and second phase signals having predetermined frequencies, respectively, and outputting first and second base band signals; a frequency discriminator for receiving said first base band signal and detecting a frequency offset; a phase detector for multiplying the output signal of said frequency discriminator by said second base

band signal and detecting a phase offset from the multiplied output in order to lock the output signal of said phase splitter into the phase of the second base band signal; and a digital oscillator for oscillating into a pilot signal of predetermined frequency according to the output signal of said phase detector and generating said first and second phase signals.

Preferably, said digital oscillator comprises a numerically controlled oscillator (NCO).

Preferably, said first and second signals are an I (in-phase) signal and a Q (quadrature) signal, respectively.

Said pilot signal having a predetermined frequency is preferably a pilot tone signal of 3.65MHz.

Preferably, said first and second phase signals are sine and cosine wave signals, respectively, each having a pilot tone frequency of 3.65MHz.

Said pilot signal can be positioned in a low frequency band among predetermined high-definition signal bands.

Said frequency discriminator may comprise: an automatic frequency control low pass filter (AFC LPF) for outputting a beat signal which is generated by a difference in frequency between the output of an internally-installed voltage controlled oscillator and said pilot signal output from said complex multiplier; and a limiter for limiting said beat signal output from said AFC LPF to a signal having a constant amplitude.

Preferably, said phase detector comprises: a multiplier for multiplying the output signal of said frequency discriminator by said second base band signal; and an automatic phase control low pass filter (APC LPF) for converting the output signal of said multiplier into a direct current signal.

According to a second aspect of the invention, there is provided a receiver for receiving a high-definition signal, comprising: a tuner for converting a high-definition signal of a radio frequency (RF) band into an intermediate frequency (IF) signal; an analog-to-digital (A/D) converter for converting said IF signal into a digital IF signal according to a sampling clock signal having a frequency which is predetermined multiple of the transmission rate of said high-definition signal and lower than said IF frequency; and a digital demodulator for removing frequency and phase errors existing in said digital IF signal and converting the error-removed digital IF signal into a base band signal, wherein said digital demodulator comprises a digital demodulator in accordance with the first aspect.

Preferably, said pilot signal is controlled by a tuner so that said pilot signal can be positioned in a low frequency band among predetermined high-definition signal bands.

According to a third aspect of the invention there is provided a digital demodulation method for demodulating a digital signal into a base band signal, said digital demodulation method comprising the steps of: (a) outputting said digital signal into first and second signals respectively having a real number component and an

imaginary component; (b) multiplying said first and second signals by first and second phase signals having predetermined frequencies, respectively, and outputting first and second base band signals; (c) receiving said first base band signal and detecting a frequency offset; (d) multiplying said second base band signal by said detected frequency offset and detecting a phase offset from the multiplied signal; and (e) generating said first and second phase signals having a predetermined frequency of a pilot signal for compensating for said detected frequency and phase offsets and feeding the result back to said step (b).

Preferably, said first and second signals are an I (in-phase) signal and a Q (quadrature) signal, respectively.

Said first and second phase signals are sine and cosine wave signals, respectively, each having a pilot tone frequency of 3.65MHz.

Another aspect of the invention comprises a method for demodulating a received signal, a digital demodulation method comprising the steps of: (a) converting a received high-definition signal of radio frequency (RF) band into an intermediate frequency (IF) signal; (b) sampling said IF signal to a frequency being a predetermined multiple of transmission rate and being lower than the IF frequency and converting the result into a digital IF signal; and (c) demodulating said digital IF signal into a base band signal, wherein said step (c) comprises the substeps of: (c1) outputting said digital IF signal into first and second signals respectively having a real number component and an imaginary component; (c2) multiplying said first and second signals by first and second phase signals having predetermined frequencies, respectively, and outputting first and second base band signals; (c3) detecting a frequency offset from said first base band signal; (c4) multiplying said second base band signal by a detected frequency offset and detecting a phase offset from the multiplied signal; and (c5) generating said first and second phase signals having a predetermined frequency of a pilot signal for compensating for said detected frequency and phase offsets and feeding the result back to said step (c2).

Said first and second signals may be an I (in-phase) signal and a Q (quadrature) signal, respectively.

Said first and second phase signals may be sine and cosine wave signals, respectively, each having a pilot tone frequency of 3.65MHz.

For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings, in which:

Figure 1 is a block diagram of a high-definition TV (HDTV) receiver according to a GA-VSB method;

Figure 2 is a block diagram of an HDTV receiver to which the present invention is applied;

Figure 3A is a spectral view showing the frequency

of an output signal of the double-conversion tuner shown in Figure 1; Figure 3B is a spectral view showing the frequency of an output signal of the double-conversion tuner shown in Figure 2;

Figure 3C is a spectral view showing the frequency of the output signal of the double-conversion tuner, which was sampled by the A/D converter shown in Figure 2;

Figure 4 is a detailed circuit diagram of the digital demodulator shown in Figure 2;

Figure 5A is a spectral view showing the frequency of an output signal of the phase splitter shown in Figure 4;

Figure 5B is a spectral view showing the frequency of an output signal of the complex multiplier shown in Figure 4; and

Figure 5C is a spectral view showing the frequency of a demodulated signal.

Referring to Figure 2, an HDTV signal is received through an antenna. An RF signal of the HDTV signal received by a double-conversion tuner 202 is mixed with a first LO frequency, thus outputting a first IF signal having a predetermined frequency (920MHz). The amplitude of the first IF signal is constantly controlled according to an AGC signal generated by an AGC generator 220. The gain-controlled IF signal is mixed with a second LO frequency and converted into an IF band signal of 44MHz.

A double-conversion tuner 102 shown in Figure 1 receives the first LO frequency according to channel selection through an unshown microprocessor and the synthesizer 104, and a second local oscillation frequency from the VCO 130 of the FPLL circuit 111 corresponding to an analog demodulator. However, in the double-conversion tuner 202 shown in Figure 2, a first LO frequency with respect to each channel is directly controlled by a microprocessor 204, and a second LO frequency becomes a predetermined fixed frequency.

The double-conversion tuner 202 passes a signal having a bandwidth that is slightly larger than the desired signal bandwidth, so a co-channel signal is also output, resulting in lowered performance of the receiver. Thus, a SAW filter 206 serves as a band pass filter having an excellent cut-off characteristic for removing the passed co-channel signal.

An IF amplifier 208 outputs a signal passed through the SAW filter 206 as a signal having a constant amplitude, according to the AGC signal generated from an AGC generator 220.

The sampling frequency of an A/D converter 210 for converting the output signal of the IF amplifier 208 into a digital signal is 21.52MHz being twice the transmission

rate (10.76MHz) of an HDTV signal. The sampling point in time is determined by a symbol timing restorer 216. Thus, the present invention uses a frequency that is twice the transmission rate without using a predetermined multiple of the IF frequency as the sampling frequency, so that a low-speed A/D converter can be used.

A DC remover 212 removes a DC component generated by the nonlinear characteristic of the A/D converter 210, since the DC component acts disadvantageously as interference noise with respect to an actual signal after completion of demodulation. A digital demodulator 214 removes frequency and phase errors existing in a received signal using a digital IF signal and converts the result into a baseband signal which can be processed by an HDTV signal processor 222.

A symbol timing restorer 216 restores a symbol timing signal from the output of the digital demodulator 214 to thereby predict the sampling point of the A/D converter 210. A synchronous signal detector 218 detects various synchronous signals using the output of the digital demodulator 214 and outputs the synchronous signals necessary for each portion to an HDTV signal processor 222, and detects a data segment synchronous signal. The AGC generator 220 generates an AGC signal according to the amplitude of the data segment synchronous signal and applies it to the double-conversion tuner 202.

As is well-known, the HDTV signal processor 222 can be constituted of an NTSC removing filter for preventing degradation of an HDTV signal caused by an NTSC signal under a co-channel condition where the HDTV signal and the NTSC signal are broadcast simultaneously, an equalizer for removing multipath noise which is generated while a transmission signal is passed through a transmission channel, a phase tracking loop (PTL) circuit for removing phase noise (phase errors) not removed by a digital demodulator 214, a Trellis decoder for slicing and convolution-decoding the output of the PTL circuit in order to protect the output thereof from burst interference such as impulse noise or NTSC co-channel interference, a deinterleaver for deinterleaving the output of the Trellis decoder, a Reed-Solomon (R/S) decoder for correcting errors of the deinterleaved data using a parity, and a de-randomizer for outputting the error-corrected data as a pseudo-random sequence (PRS) code.

Meanwhile, Figure 3A shows the frequency spectrum of an output signal of the double conversion tuner 102 shown in Figure 1, and Figure 3B shows the frequency spectrum of the output signal of the double-conversion tuner 202 shown in Figure 2.

The double conversion tuner 202 proposed by the present invention is characterized in that it makes a pilot tone signal of a received HDTV signal be positioned at a low frequency portion among a signal band of 6MHz, as shown in Figure 3B. This can be easily realized if a second fixed LO frequency of a local oscillator in the double-conversion tuner 202 is changed by the micro-

processor 204.

That is, only when the output spectrum characteristic of the tuner 202 is the same as that shown in Figure 3B, aliasing does not occur although the sampling rate of the A/D converter 210 is set as 21.52MHz. If the output spectrum characteristic of the tuner 202 is the same as that shown in Figure 3A, the sampling of an IF signal cannot be set to 21.52MHz.

Figure 3C shows a frequency spectrum when an IF band signal of 44MHz, being the output of the double-conversion tuner 202 shown in Figure 2, is sampled at a symbol rate of a frequency (21.52MHz) corresponding to twice the transmission rate. That is, according to Figure 3C, when the output of the double-conversion tuner 202 is sampled at a symbol rate (21.52MHz) frequency being twice the transmission rate, several signal spectrums are copied over the entire frequency band, which is based on sampling theory.

Therefore, the digital demodulator 214 converts an A/D converted received signal into a base band signal since the former is not the latter, and tracks frequency and phase offsets which are generated by the double conversion tuner 202.

Figure 4 shows a detailed circuit diagram of the digital demodulator 214 according to an embodiment of the present invention. Referring to Figure 4, a phase splitter 232 splits an input signal into real number and imaginary number components and generates complex number signals I and Q. As an example, the phase splitter 232 can include two finite impulse response (FIR) filters, i.e., a delay and a Hilbert converter each composed of an FIR filter.

A complex multiplier 234 multiplies the complex signals I and Q output from the phase splitter 232 by phase signals $(\cos\theta)$ and $(\sin\theta)$ generated from a numerically controlled oscillator (NCO) 244, respectively, thereby converting the result into a base band as shown in Figure 5B.

That is, the output of the complex multiplier 234 can be represented by the following formula (1).

$$\begin{aligned} & (I + jQ) (\cos\theta + j\sin\theta) \\ &= (I \cdot \cos\theta - Q \cdot \sin\theta) + j(I \cdot \sin\theta + Q \cdot \cos\theta) \end{aligned} \quad (1)$$

Accordingly, the real number component of the output of the complex multiplier 234 is output to the HDTV signal processor 222 shown in Figure 2 simultaneously to an AFC LPF 236, and the imaginary number component thereof is input to a multiplier 240. At this time, an initial free running frequency of the NCO 244 is set to be the same as the frequency of a pilot tone signal of 3.65MHz among pilot tone signals shown in Figure 5A.

Meanwhile, the AFC LPF 236 and a limiter 238 serve as a frequency discriminator, and presumes the

degree of a frequency offset. That is, when frequency locking is not accomplished, the AFC LPF 236 outputs a beat signal produced by a difference in frequency between the output of the internal VCO and a pilot signal output from the complex multiplier 234. The limiter 238 outputs a value "+1" if the output of the AFC LPF 236 is greater than a value "0," and outputs a value "-1" otherwise, whereby the pilot beat signal is limited to a signal (± 1) having a constant amplitude (± 1).

The multiplier 240 multiplies the output of the limiter 238 by the imaginary number component output from the complex multiplier 234. An APC LPF 242 outputs the multiplied result as a DC signal. Then, the NCO 244 adjusts a local oscillation frequency according to the DC signal and feeds the result back to the complex multiplier 234. Here, the local oscillation frequency generated by the NCO 244 corresponds to a third LO frequency. The third LO frequency shown in Figure 1 is fixed, but, in the present invention, the second LO frequency to be input to the tuner 202 is fixed, and the third LO frequency is variable.

After the frequency acquisition occurs in this way, i. e., frequency lock is accomplished, the APC LPF 242 serves as a phase locked loop (PLL), which is a low-pass filter determining the characteristics of the PLL. The output value of the APC LPF 242 is input to the NCO 244, and the NCO 244 controls phase signals ($\cos\theta$) and ($\sin\theta$) having local oscillation frequencies. Then, the phase signals ($\cos\theta$) and ($\sin\theta$) are fed back to the complex multiplier 234. Thus, the complex multiplier 234 locks the output signals of the phase splitter 232 into the phases of the phase signals ($\cos\theta$) and ($\sin\theta$).

Figure 5C shows a frequency spectrum of a desired received signal after the demodulation is accomplished by the digital demodulator 214. Accordingly, only when the IF signal is sampled to a frequency being only twice the transmission rate and passed through the digital demodulator 214, a desired result can be obtained.

As described above, embodiments of the present invention can employ a low-speed A/D converter by using a frequency that is twice the transmission rate as the sampling frequency, and can digitize the entire received signal processing by processing the demodulation digitally. Thus, a low-priced and uniformly-performance receiver can be obtained.

The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (includ-

ing any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A digital demodulator for removing frequency and phase errors existing in a digital signal and converting the error-removed digital signal into a base band signal, for use in a receiver for receiving a high-definition signal, said digital demodulator comprising:

a phase splitter (232) for splitting said digital signal into a first signal having a real number component and a second signal having an imaginary component;

a complex multiplier (234) for multiplying said first and second signals by first and second phase signals having predetermined frequencies, respectively, and outputting first and second base band signals;

a frequency discriminator (236, 238) for receiving said first base band signal and detecting a frequency offset;

a phase detector (240, 242) for multiplying the output signal of said frequency discriminator by said second base band signal and detecting a phase offset from the multiplied output in order to lock the output signal of said phase splitter into the phase of the second base band signal; and

a digital oscillator (244) for oscillating into a pilot signal of predetermined frequency according to the output signal of said phase detector and generating said first and second phase signals.

2. A digital demodulator as claimed in claim 1, wherein said digital oscillator (244) comprises a numerically controlled oscillator (NCO).
3. A digital demodulator as claimed in claim 1 or 2, wherein said first and second signals are an I (in-phase) signal and a Q (quadrature) signal, respec-

tively.

4. A digital demodulator as claimed in claim 1, 2 or 3, wherein said pilot signal having a predetermined frequency is a pilot tone signal of 3.65MHz.

5. A digital demodulator as claimed in claim 4, wherein said first and second phase signals are sine and cosine wave signals, respectively, each having a pilot tone frequency of 3.65MHz.

6. A digital demodulator as claimed in any of the preceding claims, wherein said pilot signal can be positioned in a low frequency band among predetermined high-definition signal bands.

7. A digital demodulator as claimed in any of the preceding claims, wherein said frequency discriminator comprises:

an automatic frequency control low pass filter (AFC LPF) (236) for outputting a beat signal which is generated by a difference in frequency between the output of an internally-installed voltage controlled oscillator and said pilot signal output from said complex multiplier (234); and

a limiter (238) for limiting said beat signal output from said AFC LPF to a signal having a constant amplitude.

8. A digital demodulator as claimed in any of the preceding claims, wherein said phase detector comprises:

a multiplier (240) for multiplying the output signal of said frequency discriminator by said second base band signal; and

an automatic phase control low pass filter (APC LPF) (242) for converting the output signal of said multiplier (240) into a direct current signal.

9. A receiver for receiving a high-definition signal, comprising:

a tuner (202 - 208) for converting a high-definition signal of a radio frequency (RF) band into an intermediate frequency (IF) signal;

an analog-to-digital (A/D) converter (210) for converting said IF signal into a digital IF signal according to a sampling clock signal having a frequency which is predetermined multiple of the transmission rate of said high-definition signal and lower than said IF frequency; and

a digital demodulator for removing frequency and phase errors existing in said digital IF signal and converting the error-removed digital IF signal into a base band signal,

wherein said digital demodulator comprises a digital demodulator in accordance with any of the preceding claims.

10. A receiver as claimed in claim 9, wherein said pilot signal is controlled by a tuner so that said pilot signal can be positioned in a low frequency band among predetermined high-definition signal bands.

11. A digital demodulation method for demodulating a digital signal into a base band signal, said digital demodulation method comprising the steps of:

(a) outputting said digital signal into first and second signals respectively having a real number component and an imaginary component;

(b) multiplying said first and second signals by first and second phase signals having predetermined frequencies, respectively, and outputting first and second base band signals;

(c) receiving said first base band signal and detecting a frequency offset;

(d) multiplying said second base band signal by said detected frequency offset and detecting a phase offset from the multiplied signal; and

(e) generating said first and second phase signals having a predetermined frequency of a pilot signal for compensating for said detected frequency and phase offsets and feeding the result back to said step (b).

12. A digital demodulation method as claimed in claim 11, wherein said first and second signals are an I (in-phase) signal and a Q (quadrature) signal, respectively.

13. A digital demodulation method as claimed in claims 11 or 12, wherein said first and second phase signals are sine and cosine wave signals, respectively, each having a pilot tone frequency of 3.65MHz.

14. In a method for demodulating a received signal, a digital demodulation method comprising the steps of:

(a) converting a received high-definition signal of radio frequency (RF) band into an intermediate frequency (IF) signal;

(b) sampling said IF signal to a frequency being a predetermined multiple of transmission rate and being lower than the IF frequency and converting the result into a digital IF signal; and

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(c) demodulating said digital IF signal into a base band signal,

wherein said step (c) comprises the sub-steps of:

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(c1) outputting said digital IF signal into first and second signals respectively having a real number component and an imaginary component;

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(c2) multiplying said first and second signals by first and second phase signals having predetermined frequencies, respectively, and outputting first and second base band signals;

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(c3) detecting a frequency offset from said first base band signal;

(c4) multiplying said second base band signal by a detected frequency offset and detecting a phase offset from the multiplied signal; and

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(c5) generating said first and second phase signals having a predetermined frequency of a pilot signal for compensating for said detected frequency and phase offsets and feeding the result back to said step (c2).

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15. A digital demodulation method as claimed in claim 14, wherein said first and second signals are an I (in-phase) signal and a Q (quadrature) signal, respectively.

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16. A digital demodulation method as claimed in claim 14 or 15, wherein said first and second phase signals are sine and cosine wave signals, respectively, each having a pilot tone frequency of 3.65MHz.

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FIG. 1 (PRIOR ART)

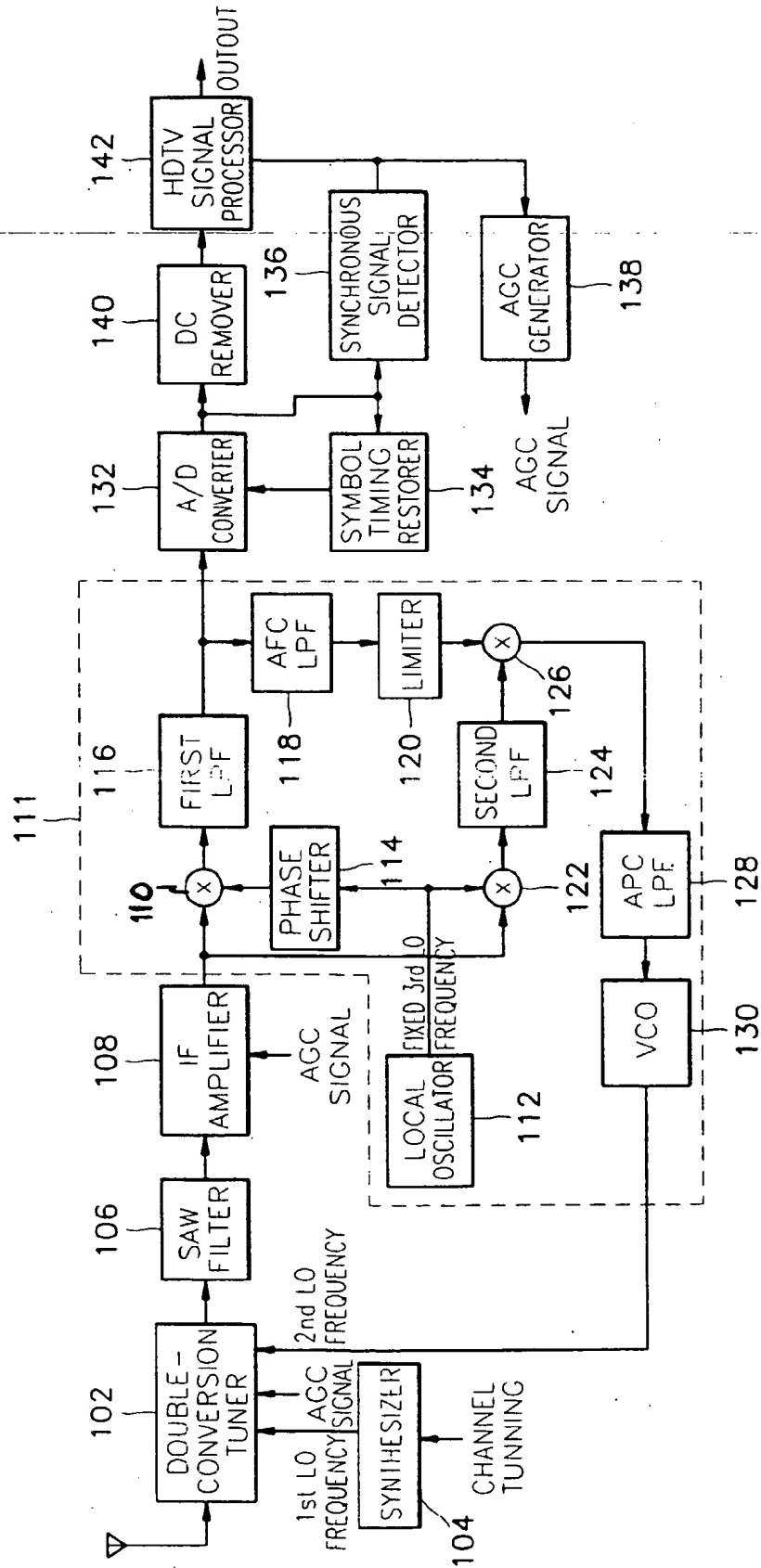


FIG. 2

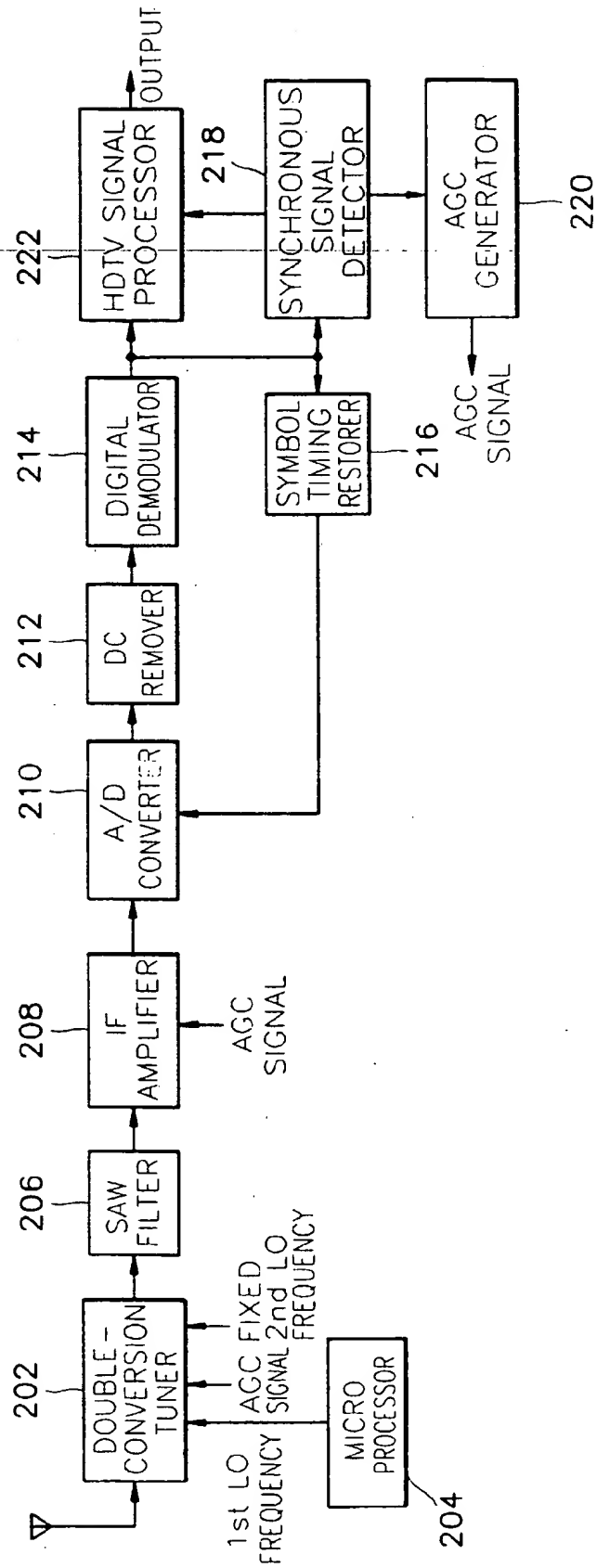


FIG. 3A

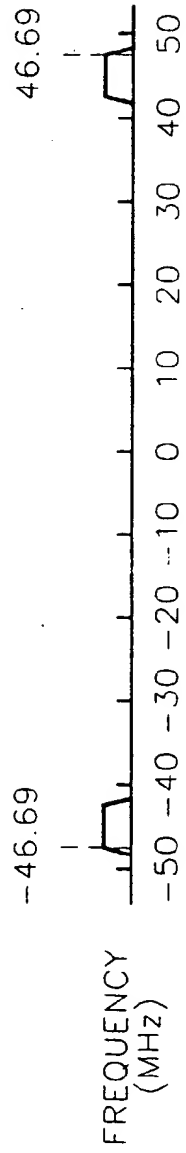


FIG. 3B

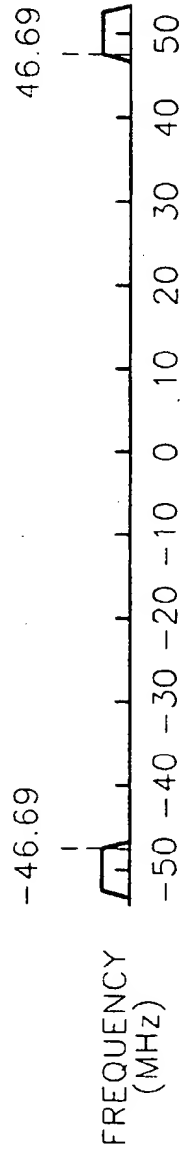


FIG. 3C

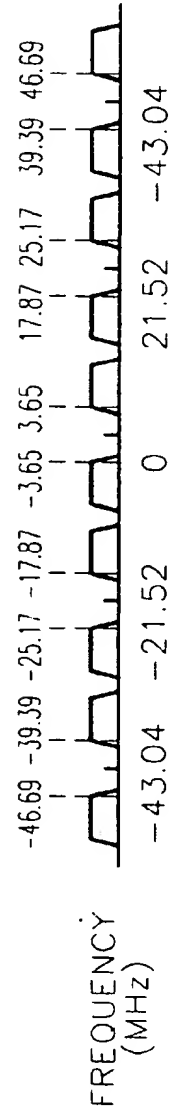


FIG. 4

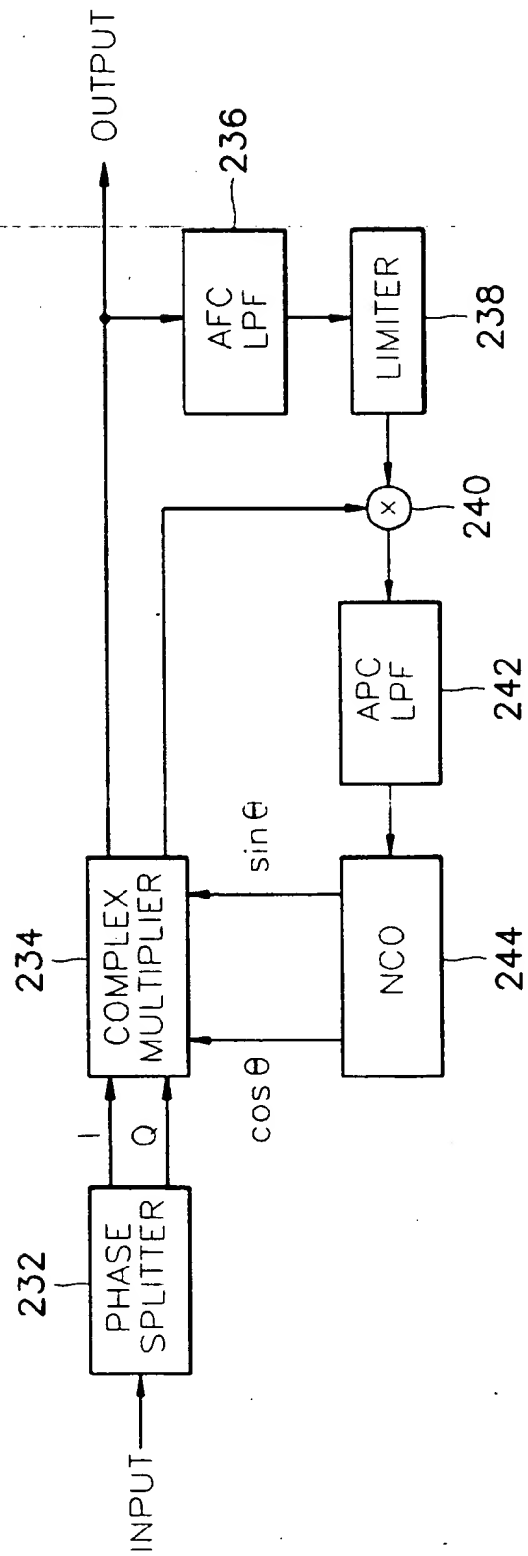


FIG. 5A

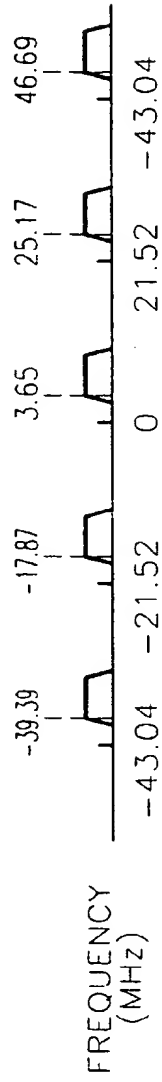


FIG. 5B

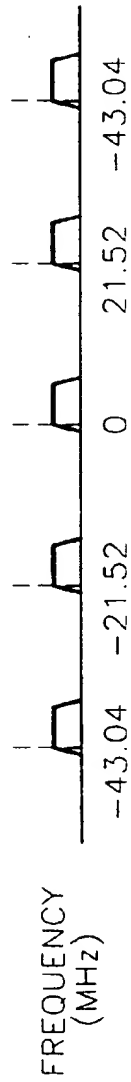
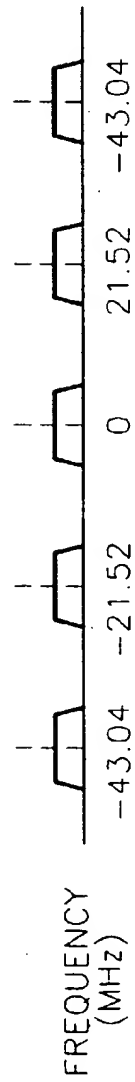


FIG. 5C





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 30 3986

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X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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